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A use for that last cup of coffee: film and paper development

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Technical Photographic Chemistry 1995 Class

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Over the past several months, the price for a good cup of coffee continues to rise and the phrase "brother, could you spare a dime?" no longer holds meaning. Consequently, after brewing and drinking a few cups of coffee, does there exist an slight irritation with the sound of coffee draining into your sink as if your loose change was going down with every drop? Why not put that unused coffee to some beneficial use? Well, we did.

The Technical Photographic Chemistry Class at RIT was engaged in an exercise to identify non-traditional developers. They tried to acquire an understanding of the selective developer molecule, and various chemical solutions were investigated, such as ascorbic acid, hydrogen peroxide and soaps to name a few. These were not successful, but why not try drinks with caffeine like tea and coffee?

Tea and coffee are rich in phenolic acids (tannins) which have the potential for supporting development. Common to all three, however, was the presence of caffeine. After stopping and fixing, the result was clear. Or should we say fogged? Development, in all three solutions, was evident, particularly in the beaker containing coffee. The class project now shifted from identification to optimization of the development characteristics of coffee.

Coffee and Development

An organic developer is usually built around a ring of carbon atoms called benzene rings. There are usually one or two electron rich groups of atoms, attached to the ring, which provide the necessary electron to initiate development. One of the oldest of these is hydroquinone, as well as, p- phenylenediamine - a common color development agent. The pH of the solution controls the function of the developer in the process.

Coffee contains just about every type of molecule known to nature, including proteins, lipids and carbohydrates, but that "go-juice" that many of us cannot do without also contains a group of molecules known as phenols. One of these is called caffeic acid (Figure 1a). Compare it with the molecule of catechol, an effective photographic developer (Figure 1b). Coffee contains several other phenols which closely match not only catechol, but also several of the other hydroxy containing developer agents used in photography. Caffeine, a molecule which is larger than a benzene ring (Figure 1c), also has all of the constituents of an effective developer.

Nature would not completely hand us coffee as a developer without modification because, as our stomachs can often attest, coffee is acidic. An agent must be added to modify the pH of the solution; thereby, sufficiently swelling the gelatin and to promote active developer diffusion to the exposed silver halide grain. Buffers are often used to perform this task. A buffer is a combination of salts, generally, which maintains a selected, often alkaline, pH. Without the pH maintenance, photographic development would be difficult to control since both acid and/or base are being generated with every silver ion to silver atom conversion within the image. In keeping with the household requirements of non-traditional development, baking soda (sodium bicarbonate) and potassium hydroxide, an active ingredient used to unclog drains, were selected as the buffering component of our developing solution.

Experimental Conditions

Film Exposure

Kodak Tri-X Pan 35mm film, bulk loaded for 36 exposures, was selected for its high speed and contrast control under varying development procedures. Coffee, you may agree, would represent an unusual development procedure. This film was loaded into a Canon A2 SLR camera equipped with a 28-200mm zoom lens. Exposure values were recorded using a Minolta Autometer (WF CCD).

Exposures were taken under studio lighting conditions; in which, two 3200K spot lights illuminated a test target or subject at an angle of 45 degrees. The camera was placed normal to the test target. The test target consisted of one Kodak Ten Step Grey Scale and a Macbeth Color Checker. A group photograph was taken under similar conditions using the same film brand. Exposures were recorded assuming an ISO rating of 200 which represents a one stop over-exposure in comparison to measurements obtained with the meter set to 400 ISO. Three rolls were exposed for each scene. Optimum exposure settings were outside the scope of our investigation.

Coffee Formulation and Development Parameters

Within the time frame of our investigation, only a limited amount of conditions could be tested. The primary objective, however, was to keep a simple cup of coffee as simple as possible. Therefore, the formulation chosen was the amount of coffee used in a "typical serving". Instant coffee, a national brand most likely hand picked by Juan Valdez, was selected in order to maintain a consistent coffee concentration. A range of pH conditions, pH= 7 to 11, was tested, and a pH 9 was selected as the optimum condition. Coffee pH was adjusted using baking soda and titrated to the desired pH with potassium hydroxide at the selected solution temperature. A temperature of 85 F was found to be the optimum development temperature which is somewhat cooler than the normal cup of coffee; however, a perfect condition for the unused coffee that remains at the bottom of the pitcher.

In summary:

Coffee	Two (2) Rounded Teaspoons
Baking Soda	Two (2) Rounded Teaspoons
Potassium Hydroxide	Added to pH 9.0 (approximately One (1) Rounded Teaspoon)
Water	12 oz. or 352 milliliters
Temperature	85 F
Time	25 minutes

The 35 mm film was developed using steel reel tanks. Plastic tank use was discouraged in order to avoid permanent staining by tannin in the coffee. In order to investigate the various conditions which would affect optimum development, each roll was cut into several segments of less than ten exposures. Replenishment, during development, was not investigated in these experiments, but this condition may be the focus of future improvements. Several agitation methods were explored; and, inversion every 30 seconds was found to yield the optimum visual results.

Development Results

Tri-X Film Development

Figure 2a,b illustrates the point that coffee can indeed be used as a moderately selective film developer. In comparison to the control (Figure 2b), the coffee developed negative (Figure 2a) portrays sufficient density to render remarkable image detail. The negative contrast range of the coffee developed image, however, measures about 2.5 times less than that found for a negative developed using D-76, see Figure 3. A maximum denisty loss and a lower gamma, when developed by the coffee method, can be explained by the apparent staining of the negative by coffee tannin. As the gelatin swells, in response to the rise in solution pH, access increases for both the phenolic developing agents and the staining polymers found in coffee. So for us coffee drinkers, the same molecules that are scrapped off our teeth during those fun- filled dental cleaning trips, are also depositing on our image. Close examination of the negative in Figure 2a reveals streaks and staining even in the film sprocket area. We speculated that the yellowish-brown cast placed on the negative may counter the contrast loss when printing.

Printing

Figure 4a,b are prints made using a research group composed negative developed in coffee and D-76. The printing was accomplished by exposing Kodak POLYMAX RC paper using an Omega Diffusion Enlarger system. The exposures required to produce sufficient image detail and contrast range were quite different for the two negatives. In comparison to the control print produced using a negative developed in D-76, Figure 4b, there was about a two stop difference in exposure required to obtain a reasonable print when using the coffee developed negative. Each exposure was made using +30M contrast filtration.

As shown in the two prints, the contrast range remains relatively flat for the print produced with the coffee negative (Figure 4a). Roughly a two-fold difference in contrast range is measured between the two prints illustrated in Figure 4. Aesthetically, one could argue that the print from the coffee negative provides a soft filtered appearance. In addition, a natural print tone, using the coffee negative, was achieved without introducing further post-development chemical step(s). If we could develop a printable negative in coffee, could be develop photographic paper using the same chemistry?

Coffee-based Print Development

An exceptional result, shown in Figure 5, was achieved when a negative developed in D-76 was used to expose the RC paper and developed in the same coffee formulation under identical conditions. With one development step, the print developed with sufficiently sharp image features and a favorable "brown" tonal quality! The brown toning represents staining much like that found in the negative. We observed a staining over the whole print, including the paper support, suggesting that the tannin penetration occurs by gelatin swelling. A development time of 20 minutes was used to produce the results shown.

Final Remarks

We tried many conditions in the short time that we spent investigating this novel development chemistry. However, much more work could be done to achieve desired results approaching commercial techniques. Unexplored parameters include replenishment development, coffee types or brands and using graded paper rather than polycontrast photographic paper. Notice we did not say refreshment development, because, we actually tried caffeine laden soft drinks but could not achieve sufficient development density. Other popular caffeinated over the counter products were also investigated without much success. The secret, therefore, may not be the caffeine but the other natural products found in coffee, that is, the phenolic family of compounds. A photographic chemical manufacturer may wish to explore natural products as a potential source of film and paper developers for environmental reasons.

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CAPTIONS:

Figure 1. Coffee Components and Catechol. (a) Caffeic Acid, (b) Catechol and (c) Caffeine. Figure 2. Negative Developed in (a) Coffee Formulation and (b) D-76. Figure 3. Transmission Density versus Ten Step Grey Scale Tablet. Figure 4. POLYMAX RC print exposed with (a) a coffee developed negative and (b) D-76 developed negative. Figure 5. POLYMAX RC Print Developed in Coffee Formulation. Participants in the study: First Row (Left to Right): Chang-geon Keum, Heather Penk, Joseph Cantor, Inh Kyung Kwak, Michelle Hill. Second Row: Asher Gelbart, Joy Cwynar, James Adams.

Third Row: Heather Reid, Barbara Lee, Marci Fingeret, Lisette Ranga, Joao Malhinha. Fourth Row: Ben Pryhoda, Lisa deBettencourt, Peyton Russell, Sean Spencer and Clay Bozard. Not shown: Nathaniel Buck and Chris Landers. The guy with the coffee cup is the one to whom correspondence should be addressed: Dr. Scott A. Williams.